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The Refraction of the Human Eye.

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Examinations of the Refraction, especially among
School Children.

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FROM

THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES.

JULY, 1885.

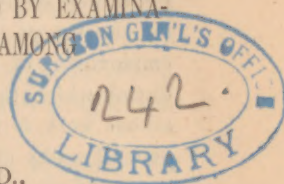


THE REFRACTION OF THE HUMAN EYE.

A CRITICAL STUDY OF THE STATISTICS OBTAINED BY EXAMINATIONS OF THE REFRACTION, ESPECIALLY AMONG SCHOOL CHILDREN.

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THE great importance of full sharpness of vision is a matter which is steadily obtaining wider-spread recognition, and is demanding still more earnest consideration of all thinking persons. Defective sight is growing more notable for a variety of reasons, and the means of amending it are progressively improving and are more widely employed, thus furnishing constant reminders of the need of such help; yet they are making only the more distinct those classes of cases which are but partially, if at all, remediable, and driving us to the more thorough study of the causes of these defects and the means for their prevention. The progress which has been made in all branches of knowledge, especially the natural sciences, is constantly increasing the field to be covered in the usual educational process. The demands made upon children at their lessons have steadily increased; while the assumption of the matter of education by the state, as a duty owing to itself and its citizens, has carried the influence of the schools, sometimes by compulsion, into every rank of life. Conditions, therefore, which not long since invested only the few, are now the environment of the community. Census reports point to a steady and rapid decrease, in every country making claim to civilization, of that portion of its inhabitants unable to read and write; while means and attractions to the exercise of these powers are offered by veritable floods of literary productions and reproductions, by postal facilities which would have been deemed a few decades since utterly beyond belief, and by an immense broadening, for almost every one, of the field of every-day interest. Some information on almost all points is expected of every one; and the most abstruse dis-

coveries of modern science in revealing new worlds, measuring the globe, or investigating its components and the creatures which live or have lived upon it, are quickly absorbed into the fund of general information, and go to widen or to modify that stock of knowledge of which all are expected to be cognizant.

And the means to the attainment of the major part of all this is the eye. Most children begin to study the alphabet and its combinations before the fifth year, and a few years more finds them all readers. School tasks surround and occupy them much of the time, and of what remains not a little is given to amusements hardly less exacting in their demands for the use of the eyes in accurate vision. The general spread of the employment of artificial illumination has lengthened greatly the hours during which the eyes can be rigorously exercised, and the child whose school work is finished turns to other reading for recreation. In the general walks of life vision, and good vision at that, is being more and more strictly required—how much we are hardly likely to appreciate at first. Yet if we think of any one, of whatever age or rank, suddenly deprived of vision, we will, perhaps, in some measure realize how essential to almost every employment is the lacking sense. How few are the paths now open to the blind, and in them, how difficult it is that they should at all cope with seeing competitors! The disadvantages of those with defective vision differ in degree rather than in kind. In every one of our eye clinics the cases are numerous where persons reject with alarm the advice that they should wear glasses, knowing, as they do, that such an assumed confession of visual defect may cost them a present situation, and will certainly count to their prejudice in seeking any new place. All this is but a fraction of the evidence showing how much is required, even outside of the schools, of the visual powers of those who have them in the usual measure.

The present century has seen the introduction of methods and instruments of precision into almost every branch of study, most notably in all which would lay any claim to scientific value. The inductive method is almost universal, and each advance is a generalization from extended observations. The observer works for the instruction of the community as well as himself; his results must receive confirmation in order to meet general acceptance; and to this end standards of comparison more or less constant and methods free as far as possible from the personal equation have become essentials. Advancing with the general realization of the importance of good vision, ophthalmology has furnished means more and more exact for the determination of the visual acuity and for the measurement and correction of its defects; until we are now in position to obtain data in these matters as strictly accurate as any in the whole range of natural science. In the mean time, investigation after investigation has been made in the

matters of vision and refraction, embracing enormous numbers of individuals, in the endeavor to answer the numerous hygienic and social questions involved in the subject of defective vision. Early realizing that, to obtain results of general applicability, eyes presumably normal must be the objects of study, and that in youth many of the causes of defect have not yet come into play, the eyes of school children have been most frequently examined, both to obtain information as to the important subject of the special hygiene of schools, and also to gain data as to what is to be regarded as the standard eye, the typical form, the normal, which the various conditions of imperfection have failed to attain. This standard determined, and the statistics of the primary variations from it once settled, we will be in position to study the questions of the general prevalence of defective vision, the causes which are effective in evoking it, and the measures to be employed in combating the evil.

The foundations of such a wide-reaching study must, of course, be broad. Furthermore, they must be sure; lest the crumbling of some of the constituents should imperil the stability of all that is built upon them. The first condition would seem well answered, since no student of the subject, not even Prof. Cohn, has up to the present time had the patience to collect all the statistics of the matter already in print; yet arrays of scores of investigations, based upon thousands of individuals, are to be found in the summaries which have been given by various authorities. In the other direction much remains to be desired in not a few of these studies, so much, indeed, that some of them can be employed in any summarizing of results only within the narrowest limits. Setting out in many instances with some single object in view, such as the question of the prevalence of myopia, attention has been given to it alone, and their negative showings in other directions are often valueless, even where the positive results are reliable. Yet they are often grouped as all equal and competent portions of evidence, and advantage is taken of their wide divergence on many important points, either to employ the convenient ones in the support of any fallacy, or else, by holding them up into view in their apparent contradiction, to throw discredit upon all such investigations and the so-called science which they in some measure represent. There has been almost no attempt to combine a critical examination of the methods, details, and results of this extensive series of investigations, with a summary embracing all that are accessible. No light work nor a pleasant one, dealing as it must with comparisons more or less odious, yet a task which the writer here undertakes in the belief that valuable results are thus to be attained. That these results will display any striking novelty is not to be hoped; but that they may give added weight to concurrent testimony derived from other sources, and perhaps widen the acceptance of views not yet receiving their due appreciation, seems abundant

reason for the labor necessary to educe them. Where a hundred investigators have expended years of study in gathering statistics on so weighty a subject, surely there is place for one to combine the data thus gathered. If only to show that much of the labor has been wasted in the past, and to give indication of the points to-day demanding elucidation and the methods by which they are to be studied out, this study would appear to be called for. That it can give or disseminate much other valuable information will, it is hoped, be made to appear.

A comparison of the numerous investigations which have been made in the field before us shows the utmost variation in their aims, methods, and results. Great as are the differences, however, the studies will repay careful scrutiny, and in few instances will we fail to find reason for discrepancies. In most of the examinations the question of the occurrence of myopia and its increase was paramount; in many, it alone was studied. Indeed, the earliest investigators knew of nothing else in our field to seek, and the methods at their command were hardly sufficient for its discovery. Even after hypermetropia and astigmatism became well known they were rarely sought with any care, and vision equal to normal was considered, sometimes even defined, as synonymous with emmetropia. In many of the investigations each eye was not separately tested, so that practically only the better eye was studied, and any difference between the two overlooked. Investigating the subject with rather vague hygienic views, the individual was quite naturally the centre of interest. If he could see with normal sharpness, whether with one eye or both, he was not a myope, and the requirements of the matter were considered to be satisfied. Among the later examinations such oversights are, naturally, rarer; yet often the meagre reports available either give no information on such points, or afford it in such indefinite terms as to leave them still in doubt.

In many of the studies the nature of the refraction has been carefully determined; but the degrees of the anomalies found have either not been determined or not reported. Others state these important details for the class, the age or the year of school life; yet, omitting the mention of the actual numbers of individuals or eyes embraced under each heading, the results, valuable as they may be in themselves, cannot be combined with those of others. In some of the cases where the ophthalmoscope was employed in the examination of every eye (and in the many where it was not used, a most important aid to accuracy was omitted), it was used to seek for lesions and not to measure the refraction. It is needless here to repeat that in the aims held by some of the investigators such details had no place; and that in studies so comprehensive in the matter of numbers examined, the introduction of the methods of extreme refinement would have been impracticable. What most concerns us is the stability, the correctness, of our foundations. The subject here taken up is the information which these examinations *can* afford as to the usual refraction of the

human eye; in health, as far as we may exclude pathological conditions in youth and in age, if the data are to be found: to extract all that is germane to our purpose. And when grave omissions or vexatious errors, generally typographical, have to be pointed out, it will be with full realization from the writer's own experience, of how hard it is to avoid error in statistical reports, and how impossible for one man to comprehend in his investigation all those points that to another may seem most interesting or essential. And if, in passing, we cannot conceal a regret that some study, most valuable in some respects, gives us no information in others, it will be with no thought of adverse criticism—rather in testimony to the value of that which is given.

To begin this study with a series of definitions, where the subject has been so much written about, may seem unnecessary, if not presumptuous. Yet, since loose employment of technical terms constitutes the principal ground of fallacy in statistics, the cardinal vice, which can make figures the most lying of witnesses, it is essential that some points be absolutely defined, and then the data of various observers be marshalled under these headings with the strictest accuracy which the details at hand will permit.

Waiving technicalities as far as possible: the *refraction* of the eye is the relation of the situation of the percipient retina to the focus of the lens system of the passive eye, for rays of light coming from distant objects. When, without any effort, the focus for such rays falls on the perceiving layer of the retina, the eye is *emmetropic*. When the eye is relatively too long to meet this condition, it is *myopic*; its retina is in position to receive the focus only of rays coming from some point not remote; it is *nearsighted*. When relatively too short, the eye is *hypermetropic*; without accommodative effort, or its equivalent, the eye can focus no rays of light that occur in nature; distant objects form undefined images upon the retina; near objects form images still less clear.

Vision is the perception of external objects through the agency of the rays of light coming from them and impressing the retina. Its acuity depends upon the formation of a sharp image upon this membrane, and upon the capacity of it, and the visual centres behind it, to take cognizance of the image so found. Granted the latter conditions in full measure, the acuity of vision depends upon the transparency of the ocular media and the refraction, primary or fictitious, of the eye. By fictitious refraction is meant every deviation from its primary condition above defined, whether produced by accommodative effort or by optical appliances, such as lenses. Conditions of imperfect retinal perception and of non-transparency of the media before it, may for our purposes be grouped under the heading *amblyopia*, and practically laid aside, and we have before us the subject of the visual acuity of the human eye as dependent upon its refraction, this last being divisible into real or primary, and fictitious or apparent, refraction. The real or primary refraction is the

object of our present search; and we will endeavor to winnow out of the mass of results furnished by a long series of investigations those which have bearing upon it, and try to solve with their aid the question—What is the normal refraction of the human eye?

Since we have at our command easy methods of determining with the utmost accuracy the visual acuity in any case; this, the most salient practical point of our study, can be directly measured; and as by wide observation we have obtained reliable data as to the average sharpness of vision, we can make ready use of it as a means to our end, only noting that the tests must be strictly applied. The farthest point of distinct vision for the myopic eye is not remote, hence normal vision at a distance without lenses at once excludes myopia: but the opposite condition of hypermetropia is far more difficult to exclude. Exercise of the accommodative power, which in the myope only makes distant vision worse, can in the hypermetropic eye cover up the defect of refraction and raise vision to the normal; nay, more, the small pupil, and probably the tension of accommodation and its effects, may raise vision above that which we hold to be the average. Vision above the normal is rather indicative of hypermetropia. The accommodation must be set aside in order to reveal the real refraction, above defined. A convex lens held before the eye will render the rays coming from distant objects convergent, and only a hypermetropic eye can focus such rays, and see normally at a distance through a convex lens. The accommodation used to render the eye apparently emmetropic is now unnecessary, and can only impair vision; it may, therefore, be laid aside, and the eye then *manifests* its hypermetropia. But a lifelong habit will not always yield in an instant. The accommodative tension may be maintained, distant vision is made worse by a convex lens, even the weakest; and we are driven to other methods to attain our aim. Dark surroundings are conducive to relaxation of accommodation, and the glare of light reflected into the eye by the ophthalmoscopic mirror may aid, or at least not counteract, the influence. This method, then, in expert hands, may as it were surprise the eye into a revelation of its defect. Yet all such measures may fail, and nothing short of absolute paralysis of accommodation by a mydriatic will tell the whole story. Irritative causes have perhaps set up a cramp of the ciliary muscle, a spasm of accommodation, which will yield but obstinately to the most powerful mydriatic.

The accommodation, then, is the factor which introduces uncertainty into the investigation; study of it can sometimes clear away doubts. The range of accommodation is at each age approximately a constant: if a part of it be called into play to cover up hypermetropia, by thus much will the range be shortened. Here we have not only a clue to the existence of such a condition, but also some indication of the amount of accommodation thus rendered *latent*; and hence of the amount of hypermetropia

neutralized. Where astigmatism is absent, very accurate results may often be thus obtained. Similar measures may be employed to determine the presence and also the degree of myopia, and to exclude the cases where nearsight is simulated by accommodative spasm; but the same difficulties may be met and nothing less than total paralysis of accommodation will enable us to claim absolute accuracy. Still more is this the case with astigmatism; and although we can in addition to other methods, get absolute results by ophthalmometric measurements as to corneal asymmetry, we have only one—the most important—of the series of factors involved.

To turn, now, to the practical workings of an examination, let us see what information we can obtain, and how we may prove the existence of emmetropia, or other conditions of refraction. Testing of the visual acuity will show it to be normal or subnormal—the former excluding myopia. If subnormal, the use of convex or concave lenses may show the presence and degree of *absolute hypermetropia* or *apparent myopia*, respectively. In all these tests each eye must be separately tried; but sometimes the testing of both together may be also advantageously employed. Convex glasses held before eyes with normal vision may reveal hypermetropia (“H. facultative manifest” of Donders), or in case of their rejection will speak for apparent emmetropia. The various tests for astigmatism may show the presence of this defect, and indicate, perhaps correctly, the meridians of greatest and least refraction in the media of the eye. These data may be confirmed by the ophthalmoscopic examination, most especially in the direct method and in retinoscopy; the cornea may be measured with the ophthalmometer, and the range of the accommodation may be determined and compared with the standard furnished by Donders. Concurrence of these various tests will greatly enhance the confidence which would be due to the findings of any one of them alone; and the presumption will be strong that eyes, which by all tests appear emmetropic, are so in fact. Only by paralysis of the accommodation, however, can this be absolutely settled, and the emmetropic eye be proven to be actually such; then no latency of hypermetropia could enlarge the list of seeming emmetropes, and no spasm of the accommodation could decrease it by causing apparent myopia. Then, too, the *degree* of any error of refraction could be exactly measured—all previous tests claiming to furnish but an approximation.

One principle must rule in all these tests. Accommodation is to be done away if possible. It can increase temporarily the refraction of the eye, lessening or covering hypermetropia, increasing the degree of myopia, or making apparent myopes of those really emmetropic or hypermetropic. There is nothing tending to the contrary—no counter-force to oppose it or to introduce error in the other direction. The lowest grade of myopia, therefore, or the highest grade of hypermetropia, obtainable by any method of competent accuracy, is the nearest approximation to the real refraction. All data in this direction are positive; all to the contrary, merely nega-

tive. Hypermetropia proven by any one test, for example, is to be considered as the true refraction of the eye, although every other test points to the contrary. The one test, to stand thus in conflict with all others, must be well based; it should be repeated to obtain confirmation from itself; but standing still, it is to be accepted as correct—all the others are probably vitiated by the deceiving activity of the accommodation. Of the various methods of examining the eye with unparalyzed accommodation, that by the ophthalmoscope is most frequently able to act such a part. The conditions of accuracy must be fulfilled and the observer must be competent; then its findings can be maintained against any array of others, which point towards myopia, *i. e.*, in the direction in which accommodative activity would tend.

In the abstracts which follow, the original reports of the examinations have been strictly followed in every case where they have been accessible; the source of information actually employed being given in the appended bibliography, to which the numbers refer. Abstracts and reviews have also been studied to obtain all possible collateral information; in this regard, and also as a source of most quotations which have had to be made at second-hand, use having been most frequently made of the "Jahresbericht über die Leistungen und Fortschritte im Gebiete der Ophthalmologie." Our study being of *eyes* and not individuals, this as well as convenience or conciseness has here and there dictated a recasting of the forms in which the results have been given; but effort has been made to do the least violence consistent with our needs to the observer's own arrangement, and none whatever to his actual results. Occasionally, palpable error in the summing up given by the examiner has driven us to work over his detailed results, and figures have been thus obtained differing (rarely in notable degree) from his totals. Information as to the actual *numbers* being more important to our ends than percentages, these numbers have been worked out when not given—always with the proviso that they are merely approximations. All results which are not in perfect accord with those of the investigator cited are indicated by parentheses, or, if derived by the writer from percentages, etc., by brackets. The varying nomenclature and standard of the schools in which many of the investigations have been made, and of their classes, makes uniform arrangement in this regard well-nigh impossible. The designation of the equivalent American school has been sometimes given, but the untranslatable "Realschule" and other similar terms, have been retained. Age, being looked upon as the best basis of comparison for our purposes, has been so employed whenever the data permitted. As to the "Gymnasium," it may be remarked that its curriculum extends generally from the fourth year of school-life about as far as the Sophomore studies of our American colleges; while in the "Realschule" the course is approximately parallel, but with lighter stress upon the classical studies.

No. Date.	Examiner.	Character of examined.	Age.	Persons.	Eyes.	Em. per ct.	M. per ct.	H.m. per ct.	H. per ct.	A.s. and Amb.
1 1813	Ware	Foot guard, England	....	1,000	....	0-4.7	0-4.7	....	....	....
2 1848	Szeklak	Chelsea Military school, England	....	1,300	....	3 0.25.2	3 0.25.2	....	....	....
3 1866	Schünmayer	University students, Oxford	....	1,357	....	32 25.2.7	32 25.2.7	....	....	....
4 1861	v. Jaeger	Primary scholars, Paris	....	6,300	....	114 [11.6]	114 [11.6]	....	....	....
5 1866	Kock	Primary scholars, Paris	....	975+	....	46 4.9	46 4.9	....	....	....
6 1867	Kock	Primary scholars, Paris	....	930	....	392 18.4	392 18.4	....	....	....
7 " "	Alexander	Grammar-school pupils, Baden	....	2172	....	416 30.4	416 30.4	....	....	....
8 " "	Gaerner	Normal children and adults, Vienna	19, 258.	8804	700	223=31.8	223=31.8	....	....	....
9 " "	Gaerner	Free school pupils, Leipzig	....	213	2514.1	[12]	48 [22.5]	55= [25.8]	61=8.7?	....
10 " "	Thilenius	School children, Brunswick	....	2250	....	....	....	....	....	....
11 " "	Thilenius	Primary scholars, Aix	....	889	....	231 83.7	231 83.7	....	....	....
12 " "	Thilenius	Technical graduates, Tübingen	4-19	138	276	41=11.9	41=11.9	16= 1.1	....	Am. 34
13 1870	Schulz	Village primary pupils, Breslau, etc.	6-13	166	....	140= 94.7	140= 94.7	127 2.5	....	....
14 1871	Erismann	City elementary pupils, Breslau	6-14	478	....	424= 85.3	424= 85.3	32 4.12	....	....
15 " "	Geln	Secondary and grammar pupils, Bress.	7-17	1269	....	182 7.9	182 7.9	44 1.9	....	....
16 " "	Geln	Real-school and grammar pupils, Breslau	9-22	2336	....	1682 7.2	1682 7.2	15 3.7	....	....
17 " "	Kruger	University students, Breslau	17-27	410	....	134 32.7	134 32.7	10 7.6	....	....
18 " "	v. Hoffmann	Type-setters, Breslau	20-71	132	....	51 38.7	51 38.7	9 2.9	....	....
19 1873	v. Hoffmann	Gymnasium scholars, Rostock	....	314	....	175 55.7	175 55.7	....	....	....
20 " "	v. Rons	Gymnasium scholars, Lipsia	12-16	431	....	1132 28.	1132 28.	159 36.9	....	....
21 1874	Ott & Ritzmann	Pupils of various schools, St. Petersburg	8-24	4338	....	[App. Em. 67]	1317 30.2	1889 43.3	(Atropine)	....
22 " "	Ott	Village scholars, Silesia	6-13	240	480	14 3.	4 0.9	370 77.	438=91.2	24
23 " "	Geln	School children, Russia	....	769	....	482 33.5	254 34.5	23 3.	....	....
24 " "	Kruger	Gymnasium pupils, Breslau	6-22	361	....	187 32.	125 35.	25 7.	....	....
25 " "	v. Hoffmann	Gymnasium pupils, Frankfurt	9-19	263	406	150 39.	162 40.	72 17.7	83 27.6	....
26 " "	v. Hoffmann	Gymnasium pupils, Wiesbaden	9-19	256	512	140 27.3	187 36.5	[101 19.7]	171 33.8	9
27 " "	v. Hoffmann	Girls prep. & gram. pupils, Wiesbaden	6-15	403	....	293 30.4	83 24.6	87 21.5	194 33.7	23
28 " "	v. Hoffmann	Girls prep. & gram. pupils, Wiesbaden	6-18	563	....	321 36.5	67 12.	37 6.5	145 25.5	35
29 " "	v. Hoffmann	Gymnasium pupils (1872), Vienna	....	409	818	243 26.7	375 45.8	138 19.3	[184]	42
30 " "	v. Hoffmann	Gymnasium pupils (1872), Vienna	....	389	....	144 37.	169 47.7	69 17.7	....	4
31 1874	Ott & Ritzmann	Gymnasium pupils, Schaffhausen	....	122	244	124 51.	96 39.3	24 10.	....	....
32 " "	Ott	Real-school pupils, Schaffhausen	12-14?	164	324	146 45.	37 11.1	122 37.7	....	....
33 " "	Geln	Old villagers, Silesia	60-84	100	200	49 24.5	25 12.5	114 57.	114 57.	Aa. 19
34 " "	Gayot	Pupils of various schools, Lyons	6-14	690	....	440 73.3	52 8.7	108 18.	....	12?
35 " "	Burgl	Girls grammar school, Munich	10-17	179	....	[24] 40.	88 49.2	19 10.7	....	....
36 " "	For	Real-school pupils, Bonn	10-18	490	....	279 46.9	135 24.	18 4.18	....	....
37 1875	Callan	Negro prim. & grammar school, N. York	5-19	437	480	81 17.7?	12 2.6	289 67.	350 76.5	....
38 " "	v. Rous	Gymnasium pupils, Vienna	....	....	....	139 33.1	177 34.6	49 10.5	182 28.3	....

1 Only those having eye-trouble were sent for examination.

No. Date.	Examiner.	Character of examined.	Age.	Persons.	Eyes.	Em. per ct.	M. per ct.	H. m. per ct.	H. per ct.	As. and Amb.
39 1875	Phleger	Teacher recruits, Switzerland	20-25	529	3036	909=25.94	112=21.2	337=11.76	1441=47.47	
39 1876	Conrad	Gymnasium pupils, Königsberg	6-40	1518	100	64 32.	678 22.33	126 63.		
31 "	Aller	Deaf mute pupils, Vienna	8-19	100	203	.....	214 11.2			
32 "	Spelling	Primary and Grammar pupils, Portland	6-15	2572	1846	892 46.	181 10	800 44.		
33 "	Phleger	Pupils of various schools, Lucerne	7-23	4296	422 9.82	422 9.82	542 12.61	3308 77.		
34 "	Eumert	Pupils of various schools, Bern, etc.	5-55	2265	1331 67.59	448 10.78	286 12.63		?	
35 "	Loring & Derby, R. H.	Pupils of various schools, New York	6-21	746	187 25.1	371 49.7	188 25.2			
36 "	Schending	Gymnasium pupils, Erlangen	8-	.....	[106 12.4]	224 18.8	687 51.5	8 2.	[904 67.5]	As. 92
37 "	Koppe	Pupils of various schools, Dorpat	.....	661	1332	279 20.9	270 20.3			
38 "	Kochmann.	Normal scholars, Hamburg	8-20	413	240 58.	157 38.	157 38.			
39 "	"	Realschule pupils, Hamburg	.....	232	.....	.....	[60 26.			
"	"	Grammar scholars, Hamburg	.....	310	.....	.....	[77 25.			
"	"	Pupils of girls private school, Hamburg	.....	104	.....	.....	[18 17.			
"	"	Pupils of girls private school, Hamburg	.....	218	.....	.....	[48 22.			
"	"	Girls' normal school pupils, Hamburg	.....	45	.....	.....	[19 42.			
"	"	Primary scholars, Hamburg	.....	296	.....	.....	[36 12.			
40 "	Classen	Realschule pupils, Hamburg	.....	402	.....	.....	165 41.	34 5.5		
41 "	Bacon	District scholars, Hartford	7-17	308	616	464 75.3	102 16.5			
42 "	Steven	District scholars, Hartford	7-17	675	.....	.....	[120 18.			
43 "	Becker	Gymnasium pupils, Heidelberg	.....	287	.....	154 53.	100 35.	33 12.		
"	"	Grammar pupils, Heidelberg	.....	261	.....	.....	[34 13.			
"	Agnew [Williams & Ayres]	Primary district pupils, Cincinnati	.....	639	.....	307 80.5	85 13.5	37 6.		
"	" [Chatham]	College students, New York	.....	549	1097	651 59.	333 30.3	165 9.6		
"	" [Prest & Mathewson]	Teel. Institute pupils, Brooklyn	.....	30	600	372 62.	79 12.5	126 21.		
45 "	Derby, Basket	College freshmen (Harvard) Boston	.....	122	.....	.....	[365 29.2			
46 "	Niemann	Gymnasium pupils, Magdeburg	.....	325	.....	.....	[156 49.			
"	"	Gymnasium pupils, Magdeburg	.....	388	.....	.....	[171 44.			
47 "	Cohn	Watchmakers, jewelers, lithographers, Breslau	10-71	172	.....	116 67.4	28 16.2	25 14.5	.....	As. 3
48 "	Dor	Lycium pupils, Lyons	5-23	1016	2026	1300 64.	568 28.	= or 1 10.		
49 Ott	Siegel	Gymnasium pupils, 1876, Schaffhausen	.....	120	240	90 37.5	98 40.8	87 4.2		
50 "	Reich	Recruits, grad. of gym., etc., Munich.	18-24	284	.....	.....	161 38.	62 21.6		
51 "	Burchardt	Pupils of various schools, Caucasus	.....	1250	.....	[329] 42.7	[365] 29.2	.....	[425] 34.7	=5.
52 "	Roscoe	Gymnasium pupils, I and II, Berlin	.....	61	122	.....	76 62.3	.....	
53 "	"	Med. Students and graduates, N. York	21-31	14	.....	3 22.	.....	0 0	11 78.	
54 "	Hamel	Gymnasium pupils, II & I, Hesse	.....	177	354	.....	[200 30.3]	202 23.7		
55 "	"	Industrial school, boys, Dresden	6-15	432	854	470 55.	182 21.3	238 31.2		
"	"	District school, girls, Dresden	6-14	382	764	317 41.5	299 27.3	121 16.4		
"	"	City school, boys, Dresden	6-14	308	736	429 58.5	185 25.3	151 20.8		
"	"	City school, girls, Dresden	6-14	364	729	400 58.3	160 22.9	151 20.8		
"	"	Girls school pupils, Dresden.	7-14	171	337	187 55.5	95 28.2	53 16.3		

2 The percentages foot up 110 per cent. through a typographical error.

1 Perhaps the same as No. 112.

3 Atropine.

No.	Date.	Examiner.	Character of examined.	Age.	Persons.	Eyes.	Em. per ct.	M. per ct.	H. per ct.	H. per ct.	As. and Amb.
1878	1878	Hannel	Real-school, Dresden	8-17	269	417	[24-48.5]	161 38.5	52-12.4		
"	"	"	Kreuzschule, Dresden	8-21	354	1100	[40-41.5]	554 50.	86 7.8		
"	"	"	Gymnasium, Dresden	8-21	480	953	[40-46.9]	448 46.8	54 5.02		
"	"	"	Royal Seminary, Dresden	13-21	218	432	[164 37.9]	236 31.8	32 7.4		
"	"	"	Private Seminary, Dresden	13-20	131	291	[103 39.5]	134 31.3	24 8.2		
56	1879	Derby, Haskett	College freshmen, Andover	15-24	321		[145 45.2]	114 35.9	67 20.9	?	
57	"	Horstmann	Young children (Berlin?)	8-24m.	57	96	13 13.5	9 9.4	.....	(Atropine) 74=77.	
58	"	Netelzka (vide 82)	Pupils of various schools, Graz	.....	1229	2458	[1426 57.5]	735 29.9	234 9.3	[1690 67.3]	
59	"	Just	Pupils of various schools, Zittau	.....	1717	3134	.....	522 15.5	.....	(37)	
60	"	Niehl	Primary and lyceum pupils, Marcellines	3m-46y	26	51	14 28.	0 0.	85 71.4		
61	"	Kotelnann	Uncivilized, Hamburg	8-17	283	566	182 31.02	110 19.43	273 48.83		
62	"	"	Gymnasium pupils, Wandsbeck	7-13	1686		.....	86 5.33	.....	
63	1880	Smith, Priestley	Pupils of Board-schools, Birmingham	18-23	357		.....	72 20.	.....	
"	"	"	Pupils of normal schools, Birmingham	1-60d.	111	154	21 14.	27 18.	.....	(Atropine) 106 69.	
64	"	Ely	Infants, New York	1-2nd.	40		.....	4 10.	.....	(Atropine) 28 70.	
65	"	Horstmann	Infants, [Berlin?]	1-2nd.	1133		8 20.	95 8.4	133 11.7	(133 11.7)	
66	"	Dennett	Pupils of various schools, Hyde Park	4-20	337		8 20.	268 7.9	.....	
67	"	Behem-Schwarzbach	Pupils of various schools, Australia	8-17	104		15 14.4	3 2.9	86 82.6		
68	"	"	Masri children, Australia	10-15	203		36 8.9	52 12.8	318 78.3		
69	"	Emmert	Gymnasium pupils, Berne	6-15	2041		.....	[800 65.5]	72 3.5		
70	"	Florschütz	Pupils of var. schools [1873, Coburg]	6-20	2323		1329 65.1	431 21.3	.....	
"	"	"	Pupils of var. schools [1877, Coburg]	6-20	172		242 51.2	49 14.6	.....	161 34.1	
71	"	Herzenstein	Military Gymnasium pupils, Orel	6-14	[206]		.....	212 66.6	?		
72	"	Schallbach	Gymnasium pupils, Jena	.....	281	562	10 2.	0 0.	.....	552 98.	
73	"	Netelzka (vide 82)	Pupils of primary schools, etc., Graz	<10d.	108	216	81 37.5	116 54.4	19 8.8		
74	1881	Konigsfeld	Infants (newborn), Vienna	.....	108	216	212 51.2	69 14.6	161 34.1		
75	"	von Koss	Medical students, Breslau	6-14	472		.....	212 51.2	252 8.3	824+	
76	"	Wetzer	Common school pupils, Vienna	6-14	1889	2778	11767 42.7	361 31.27	252 8.3	1792 74.1	
77	"	Risley	Higher schools, Darmstadt	9-21	1212	2422	272 11.2	332 13.7	.....	
78	"	Badal	Pupils of various schools, Philadelphia	6-21	290		.....	15 7.5	24 12.4		
79	"	Collard	Deaf-mute pupils, Bordeaux	.....	410	820	389 47.4	286 36.	158 9.3		
80	"	Westphal	University students, Utrecht	17-38	149	298	133 44.6	149 50.	16 9.3	.....
81	"	Netelzka	Gymnasium pupils, Schifflis	11-21	254		136 53.5	75 26.5	35 13.8	.....
82	"	"	Real-school pupils, Graz	.....	4934		.....	493 0.	.....	
"	"	"	Pupils of primary schools, Graz, etc.	.....	369		.....	134 33.7	.....	
"	"	"	Pupils of Grammar schools, etc., Graz	.....	1255		.....	378 30.7	.....	
"	"	"	Pupils of E. school. & Gymnasia, Graz	.....	208		.....	[10.3-30.1]	.....	
83	"	Reich	Military Gymnasium pupils, Tilsa	.....	250		257 94.8	6 2.4	4 1.6	?	
84	1882	Fox	American Indian pupils, Carlisle	8-22	76	152	119 78.35	19 12.5	14 9.25		
85	"	Paulsen	Pupils of navigational school	.....			.....	.....	.....

1 The percentages foot up 102 per cent.

No.	Date.	Examiner.	Character of examined.	Age.	Persons.	Eyes.	Em. per ct.	M. per ct.	H. m. per ct.	H. per ct.	Ass. and Amb.
83	1882	Borthen	Pupils of various schools, Thronium	6-19	550		247 -44.9	96=17.5	200=38.4		
84	"	Schubert ¹	Pupils of common school, Nuremberg	....	1012	1830	626=44.2	500=27.6	600=38.2	7	Amb. 74
85	"	Kolbert	Pupils of var. schools, Bonn	....	6163		260 -4.92	260 -4.92			
86	"	Fremming	School children 1870, St. Petersburg	....		350	?	54 (+)	15 (+)		
87	"	Mittendorf & Derby, R. H.	Primary pupils, New York	....	203		[102 80]	6	35 17.2		
88	"	"	Grammar pupils, New York	....	698		[565 79.5]	[50] 8.5	[84] 12.		
89	"	"	Grammar pupils, New York	....	896			119 13.5			
90	"	"	College students, New York	....	201			69 35	[30] 10.		
91	1883	Nordenskjöld	Pupils of Alaskan school, Paris	7-20	226	452	(319 70.5)	70 15.5	63 13.9	.....	As. 411
92	"	Mauz	Gymnasium pupils, Freiburg	....	487			141 39.2			
93	"	Berlin and Rembold	Gymnasium pupils, Freiburg	....	[885]			136 14.2			
94	"	"	Orphanage scholars, Stuttgart	7-15	3082	564		432 11.			
95	"	"	Real-gymnasium pupils, Stuttgart	....	282			106 18.			
96	"	Gaertner	Gymnasium pupils, Stuttgart	....	....			45.7			
97	"	Derby, Hasket	Theological graduates, Tübingen	4-10	575	1150	283 24.6	865 75.2	2 0.17		
98	"	Dobrowsky	College graduates, Amherst	21-26	554		57 34.3	130 47.2	47 18.5		
99	"	Dürr	High school pupils, Ural	....	212		....	[36] 12.0			
100	"	"	Lycium pupils, Hannover	[9-10]	345		46 13.3 (?)	121 35. (?)	107 33.6	(Homatropia)	
101	"	"	Seminary students, Hannover	[14-20]	96		9 9.37	32 33.3	36 37.5	(Homatropia)	
102	"	"	Real-gymnasium pupils, Hannover	[9-10]	271		....	81 30.4			
103	"	Hanson	Country school pupils, Kiel	10-14	808	1610	26 1.58	51 3.4	....		Amb. 6
104	"	Reich	Civils' institute pupils, Tiflis	....	173		40 23.1	57 33.	63 36.4		As. 13
105	"	"	Military school pupils, Tiflis	....	292		....	52 17.8			
106	"	"	Military gymnasium pupils, Tiflis	....	252		61 24.2	49 19.4	129 51.2		As. 10
107	"	Moala	Type seters, Paris	....	97		10 10.3	31 31.9	....		As. 30
108	"	Schetschepoff	Middle school pupils, Astrachan	....	600		[482] 80.33	[96] 16.5	[17] 2.83		As. [3]
109	"	Schadow	Primary scholars, Island of Berkum	6-14	146	292	44 15.1	2 0.7	....	
110	"	Radlow	Naval training sch. pupils, Greenwich	15	1074		(+2 -2)	60 5.8 (?)	....	
111	"	Tscherning	Recruits (educated), Copenhagen, etc	....	2236		(+2 -2)	(420 18.)	($\frac{91}{210}$ 3.9)		
112	"	"	Recruits (uneducated), Copenhagen	....	5187		(+2 -2)	(207 4.)	($\frac{91}{210}$ 4.05)		
113	"	v. Reuss	Railway employees, clerks, etc, Vienna	....	273		130 54.94	86 31.50	37 13.55		
114	"	"	Engineers, etc, Vienna	....	289		188 67.14	11 3.92	81 28.93		
115	"	"	Trainmen, Vienna	....	421		307 72.92	25 5.93	89 21.13		
116	"	"	Stationmen, Vienna	....	554		3.6 67.87	30 5.41	148 26.71		
117	1884	Schleich	Infants new born, Tübingen	2h-Sl.	150	300	0 0.	0 0.	....	(Atropine)	

¹ Received too late for inclusion in summaries.

² Re-examination, vide 14.

³ Corneal astigmatism was measured with the ophthalmometer of Javal & Schiötz.

No.	Year.	Examiner.	Character of examined.	Age.	Persons. Eyes.	Em. per ct.	M. per ct.	H. m. per ct.	H. per ct.	As. and Amb.
108	1884	Schäfer	Deaf-mute pupils, Heidelberg.	9-18	95	91 = 22.1	7 = 7.3	41 = 43.1	62 = 65.2	41
109	"	Segeel	Recruits common soldiers, Munich.	20-21	1226	1425 26.7	347 11.4	1250 40.6	.....	28
110	"	Ulrich	Recruits volunteers, Munich.	20-24	284	128 22.5	341 60.	71 12.5	(Atropine)	
111	"	"	Infants (newborn), Königsberg.	4h.-14d.	102	0 0.	0 0.	.....	204 100.	
112	"	Bjerrum	Infants (newborn)	7h.-14d.	87	23 26.5	3 3.4	.....	(Atropine)	
113	"	Boselin [Becker]	Girls' school pupils, Heidelberg.	8-18	250	(11. - 1.)	(\geq 1.)	.....	61 70.1	As. 16
114	"	Katclman	Girls' school pupils, Heidelberg.	5-18	380	348 60.6	(\geq 1.)	?	75 15.	As. 40
115	"	Segeel	Kalmouks, Hanau.	15-35	17	41 - 1.	(\geq 1.)	?	(\geq + 1.)	
116	"	"	Soldiers militia, Munich.	.....	118	482 65.3	62 8.4	25 73.5	154 20.8	
117	"	"	Military cadets, Munich.	.....	2296	9 25.5	0 0.	.....	.....
118	"	"	Examination pupils, Munich.	.....	320	.....	175 53.1	.....	.....
119	"	"	Girls, boarding school pupils, Munich.	.....	298	.....	208 50.	.....	.....
120	"	"	Infants (newborn), [Berlin]	7-21d.	174	.....	141 40.5]	.....	(Atropine)	
121	"	Horstmann.	Young children, [Berlin]	1-2y.	50	16 10.	6 2.	.....	88 88.	
122	"	"	Young children, [Berlin]	1-2y.	50	10 10.	6 6.	.....	(Atropine)	
123	"	Fox	Indian girls, pupils, [Carlisle]	4-5y.	50	13 13.	13 13.	.....	84 84.	
124	"	Van Ansooy	University students, Leyden.	17-33	470	327 56.33	291 31.	.....	74 74.	
125	"	Del Carlo & Pardini	Municipal scholars, Lecce.	6-16	266	(224 V=1.)	142 26.7	114 12.15	48 43.6	Mix. As. 5
126	"	Seelingo	Boys, elementary scholars, Rome.	5-10	76	73	6 4 -	7 1.2	.....
127	"	"	Boys, municipal scholars, Rome.	6-15	330	(215)	61 13.	5 0.	.....
128	"	Masini.	Girls, municipal scholars, Rome.	6-13	220	(265)	67 15.2	10 1.4	.....
129	"	"	Boys, municipal scholars, Siena.	7-15	352	(422)	81 11.5	2 0.3	.....
130	"	"	Boys, non. scholars, Castelfranco.	7-12	102	(168)	16 7.8	2 1.	.....
131	"	"	Boys, elementary scholars, Cortado.	7-14	148	(221)	16 6.4	0 0.	.....
132	"	"	Girls, elementary scholars, Cortado.	3-30	722	(1183)	190 13.1	14 1.	.....
133	"	"	Boys, element. etc., Naples, etc.	6-22	1037	(2074)	298 10.9	7 0.3	.....
134	"	"	Boys, Lyceum, etc., Naples, etc.	7-19	415	(600)	131 15.8	1 0.1	.....
135	"	"	Girls, elementary scholars, Trapani.	8-15	156	(225)	37 15.4	2 0.6	.....
136	"	"	Boys, elementary scholars, Trapani.	6-17	389	(575)	95 12.2	0 0.	.....
137	"	"	Lyceum pupils, Streggibus.	9-20	517	246 47.4	190 35.6	.....	(S1 15.69)	
138	1885	Horstmann, A. ²	Upper gymnasium pupils, Tübingen.	14-18	60	16 13.3	86 71.5	.....	14 11.6	
139	"	Randall	Medical students, Philadelphia.	19-34	90	32 18.8	17 9.44	(37 25.)	131 72.77	

1 In this group of Italian investigations the optometer of Moyné seems to have been used, and note made of only the absolute H. if any.

2 The H. was measured with the ophthalmoscope, whether it was sought with this means among the apparent Em. does not appear.

Let us now see how far the methods above sketched have been applied in the investigations which have been made; what results, positive and negative, have been obtained; and how far we can formulate corrections for such as are incomplete, and by their application bring also the inferential results to the elucidation of our subject:¹—

Beginning our study of the data given in the preceding tables by a summing up of all that can be employed on the subject of the frequency of *Myopia*, we find that we have available records of 115 investigations or groups of investigations:—

Of 146,522 examinations (individuals or eyes) M. 28,483 = 19.44 p. c.

Separating, now, those investigations giving us data as to all conditions of refraction, we have as the result of 88 investigations or groups of studies:—

90,886 exam. : Em. 43,174 = 47.73 p. c., M. 19,750 = 21.87 p. c., H. 25,635 = 28.46 p. c.

In not a few of these cases the M. designates only *apparent myopia*, the Em. comprises all with normal vision, or at best those without *manifest* ametropia;² while under H. are included, for the most part, only the *H. manifest*—the cases where the *H. total* was sought being about counterbalanced by those in which only the *H. absolute* is given. Turning now to that series of studies in which *H. total* was sought and noted with care sufficient to obtain some approximation to it, and to exclude from M. the cases of spasm of accommodation simulating that anomaly, we gain the following results from 27 studies:—

16,160 examinations : Em. 3297 = 20.40 p. c., M. 2918 = 18.01 p. c., H. 9717 = 60.13 p. c.

This is excluding Erismann's 1889 = 43.3 per cent. H. m., Emmert's 3308 = 77 per cent. H. m., Pflüger's 800 = 44 per cent. H. m., Seggel's 1239 = 40.6 per cent. H. m., and many others with even higher percentages of H. m. It is also exclusive of Just's work, since the 1660 = 67. per cent. *non-myopic* eyes, although "almost all" hypermetropic are not with sufficient clearness stated to have been H.; and Weber's, Tscherning's, and Beselin's work, although doubtless accurately done, is excluded for lack of full data as to the results obtained.

¹ Lack of space excludes the detailed accounts of the methods and results of the individual investigations which were prepared to form the body of this paper: so also as to the tables of curves which would in some measure have supplied their place as to class-results, etc. The school totals are given in the tabulation which follows. Under Em. are included all not proven ametropic; under M. all whose apparent myopia was not shown to be fictitious; under H. m. all cases of hypermetropia manifest, whether absolute, facultative, or relative; and under H. all, where any attempt seems to have been made to discover the total hypermetropia, as well as those where the methods employed are not given. Astigmatic eyes are included under H. and M. respectively, when recorded as H. As. or M. As.; under As. when not so specified.

² Gardner found among 1082 pupils of Springfield, Mass., 81 = 7.5 p. c. M., 291 = 26.9 p. c. H. m. and 69 = 6.35 As. Report of School Committee, 1884.

Combining the cases where we obtain data as to the relations of *normal vision, apparent Em.* (*i. e.*, absence of H. m.), and Em. probably such, we find :—

5347 examinations : V = 1. 4362 = 81.58 p. c., App. Em. 2578 = 48.21 p. c., Em. 147 = 27.51 p. c.

although among the Em. here noted, are still many not adequately tested, if at all, for latent H.

A similar comparison as to H. abs., H. m., and H. (generally ophthalmoscopically determined) gives :—

1378 examinations : H. abs. 59 = 4.29 p. c., H. m. 784 = 56.9 p. c., H. 1031 = 74.8 p. c. while in—

9344 examinations : App. Em. 4383 = 47. p. c., Em. 1742 = 18.6 p. c., H. m. 2076 = 22.2 p. c., H. 5284 = 56.5 p. c.

if we include Just's work, as well as others more definite. In 6873 examinations where App. M. constituted 1911 = 27.8 per cent., these figures were reduced to 1415 = 20.6 per cent. by measures calculated to eliminate more or less completely the accommodative spasm. Similar comparisons could be made on many points ; but this is sufficient to show the direction and extent of the corrections which would have to be applied to many of the studies before us in order to approximate accurate results. The actual application of such corrections can hardly be profitably made, except to very extensive summaries, and even then with great reserve ; yet we will probably be fully justified in claiming that, among the whole number thus far examined, more than 145,000 in all, not more than 20,000, or 14 per cent., were actually myopic. Similarly, of about 90,000 examined as to the relative frequency of the various conditions of refraction, some 22,000 were approximately Em. (25 per cent.), 13,000 M. (14 per cent.), 30,000 H. m. (33 per cent.), and 55,000 H. (60 per cent.).¹

Leaving this field of conjecture, and turning to the data showing the refraction at various ages, we will first study the question of the refraction of the new-born infant. Eight investigations are on record :—

	Infants.	Eyes.	Em.	M.	H.
1861. v. Jaeger, (100+)	100	5 = 5	p. c.	78 = 78	p. c.
1880. Ely,	111	154	21 14	27 18	17 = 17
" Horstmann,	20	40	8 20	4 10	106 69
1881. Königstein,	281	562	10 2	0 0	28 70
1884. Schleich,	150	300	0 0	0 0	552 98.2
" Ulrich,	102	204	0 0	0 0	300 100
" Bjerrum,	87	(87)	23 26.4	3 3.4	204 100
" Horstmann,	50	100	10 10	2 2	61 70.1
					88 88
	901+	1547	77 = 5	114 = 7.3	1356 = 87.6
			p. c.	p. c.	p. c.

All authorities are agreed that *full paralysis of the accommodation* by a mydriatic is an absolute essential in this difficult field of investigation ; and we must accept Horstmann's statement that this is attainable with

¹ Study of the degree of refraction error, of anisometropia and of many other points of cardinal importance must be reserved for a later paper.

difficulty, even when employing a solution of atropiæ sulph. 1:100. Jaeger's work, done in the earliest days of the ophthalmoscope, probably lacked that exquisite skill in the use of the instrument which later distinguished this master of ophthalmoscopy; and, further, was done without employment—certainly without the complete employment—of a mydriatic. His parallel work in the study of the dimensions of 70 eyes of infants after death, showed no instance of axial myopia; and the later studies force us to decide against his assumption of an undeveloped suspensory ligament or of a usual forward displacement of the lens, causing a *temporary* myopia of the new-born—a view negatived also by the rest of his examinations of the eyes of older children. We must, therefore, exclude Jaeger's study (albeit with much hesitation) as incompetent evidence in the matter before us. The need of "full paralysis of accommodation" leaves room for questioning of the results obtained by weak mydriatic solutions, since Horstmann failed in at least 7 instances to secure even full dilatation of the pupil with 1 per cent. solution of atropine repeatedly used. Bjerrum's finding of 23 Em. and 3 M. after (a single?) employment of atropine (0.25 per cent. solution) cannot be considered conclusive; and Ely's results of 17 per cent. Em. and 11 per cent. M. among 105 eyes under the influence of a solution (gr. ij ad ℥j) of atropine, and 8.2 per cent. Em. and 32.6 per cent. M. among 49 eyes under a weak atropine solution (gr. j ad Oj) must be similarly viewed. Accepting them conditionally, however, and doubling Bjerrum's figures to obtain the number of eyes studied by him (a procedure apparently justifiable), we gain as the result of these studies, exclusive of v. Jaeger's:—

Of 1534 eyes of infants, Em. 95 = 6.19 p. c., M. 39 = 2.54 p. c., H. 1400 = 91.26 p. c.

Only the 6 myopic eyes of Horstmann's two studies can be considered as well-established cases of M.; yet the success of Königstein and Ulrich with atropine (0.1 per cent.), and of Schleich with 0.5 per cent., in doing away with all apparent M. in their studies, lends confirmation to other results where weak mydriatic solutions were employed.

Passing on to the consideration of the refraction of children more developed, but not yet of school-age, we find, exclusive of v. Jaeger's work, only four investigations.

	Eyes.	Em.	p. c.	M.	p. c.	H.	p. c.
Koppe, Kindergarten pupils, 30	60	1	1.7	0	0	59	98.3
Horstmann, children:							
(8-24 months), 57	96	13	13.5	9	9.4	74	77
(1-2 years), 50	100	10	10.10	6	6	84	84
(4-5 years), 50	100	13	13	13	13	74	74
Total children (8 m.-5 yrs.), 187	356	37	10.4	28	7.86	291	81.75

¹ Koppe's results in the Kindergarten are impeached by himself, since he may have been measuring his own hypermetropia and not that of the observed eye. All but 18

Proceeding now to the other end of the scale of life, we find the one study of Cohn on the eyes of aged persons, mountaineer villagers in Silesia :—

100 persons (60-84 years), 200 eyes. Em. 49 = 24.5 p. c., M. 25 = 12.5 p. c., H. (m.) 114 = 57 p. c. ? 12 = 6 p. c.

A study of much interest, but of insufficient extent to be conclusive, while the individuals tested were within the region of the "hypermetropia aquisita," and of myopia due to the cataractous swelling of the lens, the "second sight" of common parlance. The other investigations of the eyes of adults have generally more bearing upon the question of the ophthalmic hygiene of various handicrafts than upon our subject, until we reach the investigations of the eyes of recruits, almost invariably young men from 20 to 24 years of age. Considering only the common soldier, whose eyes have been subjected to primary school-work alone, examinations as to visual acuity have been extensive and interesting. Thus Herzenstein found among 27,682 men of various arms, binocular vision above normal with Junge's test-types in from 71.6 per cent. to 76.6 per cent. of various garrisons about Orel and Cracow; while Rumschewitsch among 9882 recruits in the Kiew district, found 70 per cent. with V. = $\frac{120}{XL}$ to $\frac{60}{XL}$,

26.4 per cent. with $\frac{60}{XL}$ to $\frac{40}{XL}$, 4 per cent. with V. = $\frac{20}{XL}$ to $\frac{40}{XL}$, and 0.6

with V. $\frac{1}{XL}$ to $\frac{20}{XL}$.¹ The examinations bearing more strictly upon the refraction are numerous, but rarely of both convincing accuracy and fulness.² Seggel's study of the common soldiers of the Munich garrison is about the only one fully competent in its testimony, and from its extent it can well stand alone.

1526 common soldiers, 3052 eyes. Em. 1425 = 46.7 p. c., M. 347 = 11.4 p. c., H. m. 1239 = 40.6 p. c., Amb. 41.

Allowance must, of course, be made for the cases with latent H. among those noted as Em. in order to approximate full accuracy; a correction which cannot, however, be accurately formulated.

eyes, however, appeared H. > 1. D., the amount which he estimates that he manifested in this investigation, and only 2, including the 1 Em., were H < 1. D.

The Kindergarten and El. pupils were examined by the ophthalmoscope alone. In the other schools he obtained (counting As. with M. and H.) :—

by glasses,	989 pupils,	Em. 219 = 22.1 p. c.	M. 269 = 27.8	H. m. 501 = 50.7 p. c.
by ophthal.	1059 "	" 188 = 17.7 "	M. 240 = 22.6	H. 606 = 57.2 "
by oph. and gl.,	1059 "	" 112 = 10.6 "	M. 220 = 20.8	H. 711 = 67.1 "

¹ The question as to the illumination under which these results were obtained is all-important; yet many investigators are strangely silent in this regard. In sunlight $\frac{120}{XL}$ would indicate no sharper vision than $\frac{20}{XV}$ in a well-lighted room.

² Ljubinsky is cited (Nagel's Jahresb. xiv. p. 195) as having found, among 7312 sailors, Em. 48.7 p. c., M. 28 p. c., H. 43.1 p. c., and As. 2.2 p. c. (120. p. c.).

Of the data that remain all are complicated by the question of "school myopia," into which it is impossible here to enter. The persons examined were pupils of schools of every grade, generally fully engaged with their school-work, and showing at once the temporary and the permanent marks of its effect upon their eyes. Yet much information can be obtained from their study, and we will proceed to a rapid review of the refraction in the schools of various grades:—

Summing up, as before, the results of the twenty-six investigations as to myopia, we learn that in 23,315 examinations $1582 = 6.79$ per cent. M. were found. A discrimination between the real and the apparent M. in these results would lower somewhat the M. percentage, although the figures of the first two studies on the list contain no myopes below 1. D. in grade, and the last study, only those greater than 1. D.

Passing to the other conditions of refraction we find—

In 22 investigations	13,929 examinations :	Em. 857 = 63.59 p. c.,	M. 1582 = 11.36 p. c.
		H. 3764 = 27.04 p. c.	
" 10	" 3,358	Em. 491 = 14.62 p. c.,	M. 137 = 4.08 p. c.
		H. 2564 = 76.06 p. c.	

In the second series are placed those studies in which the H. t. was sought, although in Beselin's work only the $H. > 1. D.$ is reported, and here are also included Just's results, although not entirely definite in their statement—any error in the one being probably neutralized by the other. From five investigations, exclusive of Just's, we obtain:—

1835 examinations: App. Em. 767 = 41.79 p. c., Em. 371 = 20.22 p. c., App. M. 126 = 6.86 p. c., M. 53 = 3.16 p. c., H. m. 970 = 52.86 p. c., H. 1368 = 74.55 p. c.

These figures comprehend the results of Cohn's study in the mountain village of Schreiberhau, in Silesia, when atropine (in substance) was employed in most of the eyes. As various critics take diverse views of the question of the refraction under mydriatics, a few remarks upon the subject seem in place. Donders's definition of refraction fittingly opens the subject: "*By refraction of the eye*, we understand its refraction in a state of rest; that is, the refraction which the eye possesses in virtue of its form and of that of its component parts, independently of muscular action, independently of accommodation. The term, therefore, applies to the refraction of the eye whose muscles of accommodation are inactive or paralyzed (*for example under the influence of atropia*), to the refraction also of the dead but as yet otherwise unaltered eye."¹ In discussing emmetropia, however, Donders assumes a "*tone of accommodation*" which can be done away only by a mydriatic, and concludes with the often-quoted expression: "Consequently, the actually emmetropic vision requires in a certain sense a minimum of H., and that minimum is capable of no accurate taxation, because to the tone itself a certain latitude, perhaps from $\frac{1}{100}$ to $\frac{1}{10}$, must be allowed." Whether his view on this point remains unchanged we do

¹ Donders, Accommodation and Refraction of the Eye, p. 80. (Italics ours.)

Elementary Schools, etc.

Examiner.	Examined.	Age.	Pupils.	Eyes.	Em. per ct.	M. per ct.	Hm. per ct.	H. per ct.	
Cohn . . .	Country Primary . . .	6-13	1486	.....	1408=94.7	22= 1.4	16= 1.1	.....	M. > 1. D.
Cohn . . .	City Elementary . . .	6-14	4978	.....	4245 85.3	334 6.7	127 2.5	.....	M. > 1. D.
Erismann . . .	City Preparatory . . .	.....	39	.....	11 18.6	8 13.6	40 67.8	.....	Atropine.
Cohn . . .	Village Primary . . .	6-13	(240)	480	14 3.	4 0.9	370 77.	438-91.2	
v. Hofmann . . .	City Preparatory . . .	6-9	249	.....	147 59.	4 1.6	13 5.2	88 31.3	
Callan . . .	Negro Primary . . .	6-13	270	.....	18 6.6	2 0.84	213 78.9	250 92.	
Gonrad . . .	City Primary . . .	[6-9]	.....	568	155 27.3	28 5.	101 17.6	383 67.4	
Spalding . . .	City Primary . . .	6-10	1200(4)	.....	.....	84 7.	409 50.6	.....
Plüger . . .	City Primary . . .	7-10	808	.....	383 84.9	27 3.35	306 81.2	.....
Emmert . . .	Elementary . . .	6-12	367	784	103 14.	32 4.86	34 8.3	.....
Loring & Derby . . .	City Primary . . .	6-12	.....	410	348 84.9	28 6.8	.....	126 61.1	
Koppe . . .	City Elementary . . .	.....	(103)	206	53 25.7	5 2.4	.....	209 78.5	
Koppe . . .	City Preparatory . . .	.....	(136)	272	37 14.	20 7.5	173 70.	.....
Haedel . . .	City Primary (classes) . . .	.....	.....	1364	784 57.47	226 16.68	348 25.49	[492 87.5]	
Just . . .	City Primary . . .	.....	(281)	562	(433 77.)	39 10.5	39 10.5	.....
Smith . . .	City Board School . . .	7-13	1636	.....	.....	85 5.3	.....	.....
Nelotzka . . .	City and Village Primary . . .	.....	4934	.....	.....	493 10.	.....	.....
Demmet . . .	Village Primary . . .	4-10	330	.....	430 81.1	21 3.	58 10.9	.....
Florschütz . . .	City Primary, 1873 . . .	6-15	1476	.....	1035 71.3	198 13.4	60 4.1	.....
Florschütz . . .	City Primary, 1877 . . .	[6-15]	1616	.....	.....	90 3.57	.....	.....
v. Reuss . . .	City Primary . . .	6-11	237	.....	120 40.4	29 11.2	99 37.1	.....
Risley . . .	City Primary . . .	5-12	(161)	328	23 7.01	13 4.	.....	289 88.1	
Boston . . .	Common . . .	7-13	133	.....	64 48.1	8 6.	61 45.8	.....
Mittendorf & Derby . . .	City Primary . . .	.....	203	.....	[162 80.]	6 3.	35 17.	.....
Nordenfous . . .	City Primary . . .	7-13	79	.....	61 77.2	5 6.3	15 13.2	.....
Schadow . . .	Country Primary . . .	6-14	(146)	192	44 13.1	2 0.7	.....	240 82.	{ Am. > 1.
Beslin . . .	City Primary . . .	5-9	131	.....	70 53.4	4	.....	49 37.4	{ Em. > 1.

not know; but can hardly imagine so careful an observer to be still in error on this simple point. The question before us is whether this common residual tension is an *organic tonic* or an *habitual action*. That no such "tone" is ascribed to the myopic eye is curious, if the first supposition holds good. Is there, then, in the eye, a tension of the accommodation which *cannot* be voluntarily relaxed? It may be confidently asserted that an emphatic negative will be given by *every observer who has carefully tested the matter*.

The assumption of such a "tone," like the hypothesis of *negative accommodation*—really another phase of the same question—lacks the first *positive* proof in its support. Negative evidence alone, cases of *habitual spasm* of the accommodation, can be adduced in its favor; and a single positive fact, did it stand alone, would scatter such support to the winds. The investigation before us fully answers the question, although its testimony has been generally overlooked. Cohn states: "*In 34 cases with H. m. in degree from $\frac{1}{80}$ to $\frac{1}{12}$ there was no slightest increase of the H. after atropinization.*" It may be remarked that *full paralysis* of accommodation was *proven* to have been attained in these cases, although in four others who remained apparently emmetropic, Acc. = $\frac{1}{15}$, $\frac{1}{24}$, $\frac{1}{40}$, and $\frac{1}{80}$, respectively, was found remaining. Similar proof, were any needed, would be found in the investigations of Roosa (53) and Dürr (98). How two opinions on the subject can exist is the only matter of surprise to the writer, who has in hundreds of cases given the *full correcting-glass* as determined under a mydriatic pushed to complete paralysis of accommodation (and seen it done in thousands), and has rarely seen it necessary to reduce the strength of the glass because of persisting recurrence of the habitual spasm.¹ His own low H., twice measured under full mydriatic paralysis, is entirely relaxed at will, and always taken into account in ophthalmoscopic measurements. The only noteworthy point, therefore, as to the admission of Cohn's atropine work in our present study, is that *especial weight* is to be given to its showings, since in it was employed a means of accuracy lacking in others.

The group of schools in which were found the results which have been given, practically represent the first three years of school-life; and it is from this point that the course of the German Gymnasium takes its start. Intermediate schools exist in Germany as well as elsewhere, but they differ as to the upper limit of their curriculum, and in the aims and the class of the pupils attending them, rather than in the age of their scholars. While the distinction between these and the gymnasias is, therefore, very important in its bearing on the question of school-myopia, to our investi-

¹ The necessity, or, indeed, the advisability, of carrying this matter in practice to its extreme logical conclusion is a point which most ophthalmologists are by no means prepared to admit. Its *practicability* is the only question here raised, and is, in the writer's opinion, too fully demonstrated to need more extended proof.

Examiner.	Schools.	Age.	Per- sons.	Eyes.	Em. p. c.	M. p. c.	VIII.	VII.	VI.	V.	IV.	III.	II.	I.	Im. p. c.	II. p. c.					
Coln.....	Realschule.	10-22	1141	816	75.9	255	19.7	.....	16.9.	44	16.7	51	10.2	20	25.1	29=44.				
Coln.....	Gymnasium.	9-22	1195	836	72.6	314	26.2	.....	31	12.5	41	18.2	32	38.7	73	51	41.9			
Thionville.....	Gymnasium.	.....	314	175	55.7	96	36.9	.....	11.	22	36.7	13	26.	20	44.4	92	54.2			
Schultz.....	Gymnasium.	.....	431	.....	.....	169	36.9	10=26.2	10	13.4	16.	36.	33.	41	33.	41	2.9			
Erismann.....	Various.	.....	4289	1110	25.6	1251	29.7	124	13.8	262	30.7	228	33.4	296	44.3	127	42.			
Coln.....	Gymnasium.	6-22	361	187	52.	123	35.	5	13.	13	21	27.	33	52.4	25	7.	82=20.6				
Kruger.....	Gymnasium.	9-19	203	139	69.	162	40	6.7	22	22	21	26.	25	22.1	33	43.3	127	42.			
v. Hoffmann.....	Gymnasium.	9-19	256	140	57.3	187	36.5	16	19.	28	23.7	22	32.	25	22.1	33	43.3	127	42.		
v. Hoffmann.....	Gymnasium.	9-19	256	140	57.3	187	36.5	16	19.	28	23.7	22	32.	25	22.1	33	43.3	127	42.		
v. Reuss.....	Gymnasium.	.....	400	243	29.7	353	43.8	41.	40.	48.	36.	61.	58.	61.	58.	158	19.3	171	33.8	
v. Reuss.....	Gymnasium.	.....	389	144	37.	166	42.7	37.	42.	48.	36.	61.	58.	61.	58.	158	19.3	171	33.8	
Ott & Kitzmann.....	Gymnasium.	.....	122	244	124	51.	96	39.3	113	26.8	[16]	30.	[18]	47.	[14]	34.	24	10.	?	
Ott.....	Realschule.	12-14 ?	164	324	146	43.6	37	11.1	19	14.3	4	12.9	.....	.....	.....	122	37.1	?	?	
Ott.....	Realschule.	10-19	130	273	49.6	125	29.	14	8.5	19	14.3	23	34.1	23	41.1	12	40.	?	?		
Conrad.....	Gymnasium.	9-20	1254	2408	794	30.56	650	26.34	36	8.7	54	14.3	155	37.4	124	31.7	256	10.37	1058	42.9	
Spaulding.....	Grammar.	11-23	1000	439	43.9	151	15.1	14	6.3	22	14.4	26	26.6	23	34.5	34	67.	404	40.4	?	
Plünger.....	Various.	.....	1000	439	43.9	151	15.1	14	6.3	22	14.4	26	26.6	23	34.5	34	67.	404	40.4	?
Bohmert.....	Various.	.....	1781	3592	319	8.95	510	14.3	.....	.....	.....	.....	.....	.....	.....	.....	2712	76.1	?	?
Lehring & Dörfling.....	Various.	.....	1855	1183	63.8	420	22.6	.....	44	41.5	46	42.6	14	63.6	.....	.....	252	13.6	?	?
Schönding.....	Latin classes.	.....	924	134	29.6	155	34.6	.....	19	28.1	56	50.6	57	75.	50	80.6	53	80.3	29	9.7
Schönding.....	Gymn.	159	573	17.8	316	72.5	18	32	22.	31	27.	33	33	31	61.2	10	2.4	502	64.5
Koepke.....	Gymn.	.....	396	792	75	9.7	200	26.	14	14.7	16	21.	32	45.3	40	40.2	40	40.4	.....	.....
Koelmann.....	Gymn.	8-21	413	240	58.	157	38.	.....	16	21.	32	45.3	40	40.2	40	40.4	40	40.4	.....	.....
Koelmann.....	Realschule.	.....	232	.....	.....	.....	.....	.....	29.	24.	40.	40.	40.	40.	40.	40.	40.	40.	.....	.....
Classen.....	Realschule.	.....	402	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Becker.....	Gymnasium.	.....	257	154	53.	100	35.	.....	4.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Agnew.....	College.	549	1097	651	59.	333	30.3	179	26.7	71	35.	35	30.7	30	60.	18	37.5	105	9.6
Mathewson.....	Techn. Inst.	.....	300	690	372	62.	79	12.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Derby, Has.....	Coll. Freshm.	.....	122	145	45.2	36	29.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Derby.....	Coll. Freshm.	15-24	321	650	.....	114	35.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Niemann.....	Gymnasium.	.....	325	.....	.....	318	49.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Niemann.....	Preparatory.	.....	388	776	.....	340	44.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Derby.....	Gymnasium.	7-21	200	139	64.	268	28.	22	19.3	51	19.6	69	21.3	185	12.6	175	39.6	63	18.1	87	4.2
Ott.....	Gymnasium.	.....	120	210	80	37.5	38	40.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haenel.....	Gymnasium.	6-21	177	334	145	40.9	260	59.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haenel.....	Gymnasium.	9-21	480	600	430	46.9	149	46.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haenel.....	Realschule.	8-17	554	1108	190	41.5	354	50	
Haenel.....	Seminary.	13-21	218	496	164	37.6	23	53.9	

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Examiner.	Schools.	Age.	Per. sons.	Eyes.	Em. p. c.	M. p. c.	VIII.	VII.	VI.	V.	IV.	III.	II.	I.	Hm. p. c.	H. p. c.
Haezel.....	Seminary,	13-20	131	262	103	39.3	134=51.1	.....	22=37.9	25=40.3	24=51.5	16=40.	21=80.8	28=77.7	24=9.2	
Haezel.....	Secondary,	8-16	1085	2060	1028	49.9	612 28.7	70=25.2	109 22.8	156 36.2	132 39.5	.....	.....	.....	420 20.4	
Just.....	Gymnasium,	.....	164	388	(157 40.4)	612 30.3	.....	.....	26 37.1	23 32.8	21 39	48 52.	38 76.	39 67.2	27 7.	[163=49.7]
Just.....	Realschule,	.....	263	586	(264 45.1)	266 45.4	.....	.....	23 28.	31 29.2	35 38.8	46 52.3	87 58.	44 62.	24 4.1	[200 51.6]
Koelmann.....	Gymnasium,	8-17	253	566	182 31.6	110 19.4	.....	.....	12 9.5	23 18.2	27 22.1	32 22.2	14 39.	2 25.	273 48.8	
Knibb.....	Normal Sch.	18-23	357	.....	.....	72 20.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Knibb.....	Various,	10-18	603	.....	424 70.3	74 12.3	.....	.....	.....	23 9.8	19 10.5	18 16.5	10 16.6	3 33.3	76 12.6	?
Knibb.....	Gymnasium,	6-18	203	406	36 8.9	62 12.8	.....	.....	.....	.....	49.	69.7	12 88.7	7 77.	318 78.3	
Florschütz.....	Gymnasium,	8-20	177	.....	72 40.7	91 51.4	.....	.....	24.2	37.	37.5	65.5	19 65.5	.....	6 5.4	
Florschütz.....	Realschule,	10-18	260	.....	122 47.	110 42.53	.....	33.	33.3	.....	.....	.....	.....	.....	5 1.9	
Florschütz.....	" 1877,	.....	290	.....	101 34.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Florschütz.....	Gymn. 1877,	.....	182	.....	90 48.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Florschütz.....	Seminary,	17-20	44	.....	.....	16 36.4	.....	.....	.....	.....	.....	.....	.....	.....	.....
Florschütz.....	Mil. Gymn.	.....	472	1018	242 51.2	66 14.6	.....	.....	.....	.....	.....	.....	.....	.....	161 34.1	
Wheeler.....	Gymnasium,	.....	204	.....	356 34.8	403 39.67	.....	.....	.....	.....	.....	.....	.....	.....	52 7.06	[105 +]
Wheeler.....	Realschule,	.....	1018	2064	242 36.3	249 30.7	.....	.....	.....	.....	.....	.....	.....	.....	50 7.06	[70 +]
Wheeler.....	Various,	9-21	1018	2064	242 36.3	249 30.7	.....	.....	.....	.....	.....	.....	.....	.....	50 7.06	[105 71.3]
Wesley.....	Gymnasium,	.....	168	298	133 44.4	149 40.2	.....	.....	11 32	23 35.	97 54.	38 41	98 54.	22 85.	16 5.3	
Wesley.....	Realschule,	.....	254	.....	136 33.5	176 30.5	.....	16 26.8	7 16.8	8 21.	12 26.2	7 31.8	16 46.9	17 60.	35 13.8	
Wesley.....	" & Gymn.	.....	1255	.....	186 33.5	376 30.7 49	51	.....	38	47	54	53	.....	26	.....
Wesley.....	Barban	.....	417	.....	183 43.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	147 35.2	
Mittendorf & Derby.....	Grammar,	.....	698	.....	[162 80.]	60 8.5	.....	.....	.....	.....	.....	.....	.....	.....	[84] 12.	
Mittendorf & Derby.....	Grammar,	.....	896	.....	.....	119 13.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mittendorf & Derby.....	College,	.....	201	.....	[111 55.]	69 35.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Norlenson.....	Lycium,	10-20	147	.....	97 66.7	32 21.8	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manz.....	Gymnasium,	.....	[487]	.....	141 29.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manz.....	Secondary,	.....	[200]	.....	.....	52 18.5	7 11.	.....	.....	.....	.....	.....	.....	.....	.....
Manz.....	Secondary,	.....	[103]	.....	.....	74 12.2	0 0.	.....	.....	.....	.....	.....	.....	.....	.....
Bobrowsky.....	.....	.....	212	.....	.....	[23] 12.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dürr.....	Lycium,	[9-19]	318	.....	25 7.86	101 31.7	.....	9 15.5	12	8	11	22	33	23	107 33.6	Homat'p 192 60.4
Dürr.....	Seminary,	[16-20]	66	.....	9 9.4	32 33.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	Homat'p 55 37.3
Dürr.....	Real-Gymn.	[9-19]	271	.....	.....	11 30.4	.....	2 12.5	9 18.	8 16.	15 38.5	23 33.9	22 50.	2 22.2	36 37.5	Homat'p 1522 94.1
Hansen.....	Girls' Inst.	10-14	808	1610	28 1.58	51 3.4	4 1.	11 3.	10 3.	10 3.9	16 6.	.....	.....	.....	63 36.4	.....
Reich.....	Mil. Gymn.	.....	252	.....	61 24.2	49 19.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Reich.....	Mil. Gymn.	.....	252	.....	+1.-1.D.	>1. D.	.....	.....	.....	.....	.....	.....	.....	.....	.....	>1. D.
Becker.....	Grammar,	8-13	250	500	348 69.6	61 12.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	>1. D.
Becker.....	Grammar,	8-13	697	.....	+1.-1.D.	>1. D.	.....	.....	.....	.....	.....	.....	.....	.....	.....	>1. D.
Baselin.....	Grammar,	8-13	517	.....	412 67.9	38 3.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	>1. D.
Hofmann.....	Lycium,	9-20	517	.....	246 47.4	190 36.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Schleich.....	Upper Gymn.	14-18	60	120	16 13.3	86 71.6	.....	.....	22 18.2	17 20.2	38 38.8	.....	.....	.....	.....	.....

gation it is hardly more than incidental. We will group these institutions, then, by the side of the so-called "higher schools," which aim at liberal education; only premising that we are dealing now with pupils between the fourth and the twelfth school year, or between about the ninth and the eighteenth years of life.—

Combining the foregoing figures, we find as the result of examinations as to myopia in 50 gymnasiums and lyceums, 14 realschule, 7 seminaries, and about 50 other schools:—

In 55,342 examinations (individuals or eyes) 14,907 = 26.94 p. c. myopic.

Studying, now, those in which all conditions of refraction were sought, we obtain:—

In 42,763 exam. Em. 15,996 = 37.40 p. c., M. 11,757 = 27.49 p. c., H. 13,145 = 30.74 p. c., the H. probably here, as before, fairly representing the manifest hypermetropia, and the other figures the apparent myopia and apparent emmetropia, respectively. In the studies where the H. t. was sought, we find:—

In 9965 examinations Em. 2159 = 21.66 p. c., M. 2149 = 21.56 p. c., H. 5587 = 56. p. c.,

Here Just's results are again excluded, as well as those of Weber, of Becker, and of Beselin, where the figures given are confessedly incomplete and not available for our purpose; while Erismann's 1825 = 43 per cent. H. m., Pflüger's 404 = 40 per cent. H. m., Emmert's 2712 = 76.1 per cent. H. m., and Kotelmann's 273 = 48.8 per cent. H. m. are, of course, omitted. Studies of the relations of normal vision, apparent Em. and Em., of apparent M. and M., and of H. absolute, H. manifest and H. total, give results closely similar to those already set forth, and need not be here repeated in detail.

The data as to students of more advanced grade are limited, but doubtless worth summarizing:—

	Age.	Persons.	Eyes.	Em.	M.	H. m.
Cohn, Univ. of Breslau,	17-27	410		134=32.7 p. c.	244=59.5 p. c.	15=3.7 p. c.
Cohn, Medical students,		108	216	81 37.5 "	116 54. "	19 8.8 "
Gürtner, Theol. " Tübingen,	+19	713	1426	324 22.9 "	1096 76.9 "	2 0.2 "
Derby, H., Graduates, Amherst,	19-23	254		87 34.3 "	120 47.2 "	47 18.5 "
Collard, Univ. of Utrecht,	17-38	410	820	389 47.4 "	286 35. "	158 19.2 "
Van Arsooy, Univ. of Leyden,	17-38	470	939	527 66.23 "	291 31. "	114 12.15 "
Randall, Med. students, Phila.	19-34	71	142	61 42.9 "	54 10.5 "	37 26. "
	17-38	2436	4207	1593=37.86 p.c.	2207=52.46 p.c.	392=9.31 p. c.

In the first examination of this series H. abs. alone was noted; in the others the H. manifest was sought, but only in that of the writer, which ends the list, does the attempt seem to have been made to find the H. total by the ophthalmoscope or other means. In this last case the results were:—

71 Persons. 142 Eyes. Em. 30 = 21.1 p. c. M. 17 = 12.4 p. c. H. 93 = 65.5 p. c.

And for all—

90 Persons. 180 Eyes. Em. 32 = 18.8 p. c. M. 17 = 9.44 p. c. H. 131 = 72.77 p. c., figures in marked contrast to those above.

236.

Looking backward over the long array of investigations which have been here grouped together, a few words of general comment seem permissible before passing to our conclusions. It is very evident that the majority of the studies cited can make no claim to being the unimpeachable foundation for our investigation of the refraction of the human eye; indeed few have been undertaken with the solution of any such question in view. The details of the methods employed in each examination would make clearer, perhaps, than is now the case, the true status and value of each; but lack of space excludes them, and the writer is unwillingly forced to group the studies and marshal their results as his study of the original data indicates is correct, and to set them forth apparently solely upon his own authority. Careful study of the original records will show, however, that the records have been in no instance classified, recast, or emended, arbitrarily; and if any judgment has been passed not fully upheld by the data furnished by each investigator, it has only been in holding as competent some of the investigations which are not *a priori* clearly self-condemned. In view of the great preponderance of the hypermetropic refraction in all investigations where its presence has been sought with a care in any degree adequate, it must be as evident to others as it is to the writer, that many of the studies giving low percentages in this matter cannot be correct. Such a conclusion, however, would by many be deemed a result of reasoning *a posteriori*, and has not been here drawn. For the figures given, unimpeachable accuracy cannot be claimed, especially when the sources from which they are derived are rarely free from palpable errors; and confusion and error are too easy of entrance to have been entirely excluded in the writer's own work. All that repeated careful revision and verification can do has been sedulously employed to secure correctness, and where possible the data have been submitted for verification to the investigators themselves, to many of whom the writer's thanks are therefore due.

It is then evident, that for the solution of the broader questions of the prevailing condition of refraction and other similar generalizations, few of the investigations thus far made are fully available; and it is to be hoped that future students of the subject will recognize these shortcomings and furnish us with fuller, broader, and more accurate data. The opportunities to employ mydriatics in extensive studies will continue to be very rare; it is therefore incumbent upon those who shall have such chances, if they would contribute fully to the elucidation of this important subject, to furnish at the same time data as complete as possible as to the vision without and with glasses, the accommodation and the apparent refraction, before the mydriatic, as well as the intraocular condition and the functional comfort of the eyes; and to furnish proof, where possible, that the mydriatic had been pushed to *full* paralysis of accommodation. Thus only can the strict requirements of the subject be met. For those

who are debarred from the use of mydriatics, combination of all other methods of study is necessary, if they desire to render as slight as possible the doubt which must always attach to determinations of the refraction made in eyes with unparalyzed accommodation.

The following conclusions seem fully upheld by the results of the investigations thus far made:—

1. Myopia is almost unknown in infancy and very infrequent before the beginning of school-life. In the earlier school-years its percentage is still low and it is only in the advanced classes, especially of the German schools, that it ever attains to a preponderance. It has been found in not more than $39 = 2.54$ per cent. of 1534 eyes of infants, in not more than $28 = 7.86$ per cent. of 356 eyes of children under the school-age, and in only $1582 = 6.79$ per cent. of 23,315 eyes of children examined during the first three school-years—figures which more accurate methods might have made lower. Among 3052 eyes of young men, upon whom the school influence had not been excessive, it was found in $347 = 11.4$ per cent.—a percentage which probably oversteps the maximum which it is likely to attain outside of the schools.

2. Hypermetropia is the enormously preponderating condition in infancy and early childhood, and the first years of school life witness little reduction in its proportion. Outside of the schools it remains by far the most frequent refraction throughout life, and in the schools it is decreased by the change of eyes to the myopic refraction in a degree apparently varying according to the circumstances calling into existence that defect. It was found in $1400 = 91.26$ per cent. of the 1534 eyes of infants examined, in $291 = 81.75$ per cent. of the 356 eyes of young children, and in $2564 = 76$ per cent. of the 3358 eyes of children in the elementary school years, among whom it was sought with adequate care. So also in the higher schools, it constituted at least 56 per cent. of the whole number of eyes studied by competent methods, being found in 5587 of the 9965 examined.

3. Astigmatism has been rarely sought with care, and the data with regard to its frequency are not sufficiently wide to justify definite conclusions. The findings of the studies where it has been well looked for, concur with the clinical work in indicating a measurable degree of astigmatism (0.5 D. or more) in the majority of ametropic eyes.

4. Emmetropia in a mathematically strict sense has probably no existence. Approximate emmetropia (Am. $< \pm 0.5$) is infrequent in all ages, probably at no epoch exceeding 10 per cent. Its apparent proportion is swollen by the array of eyes "*not proven*" ametropic, and we have but few studies where the accommodation has been with certainty set aside and its existence fairly well shown. Cohn among 299 atropinized eyes proved in no single instance its presence. Under homatropine Hansen found it in but 26 of 1610 eyes, and Dürr in 30 of 414 eyes: it consti-

tuted at most $60 = 2.6$ per cent. of these 2323 eyes. Among the infants and young children $135 = 7.36$ per cent. of the 1834 examined under atropine may have been emmetropic; and Roosa's brief study indicates that it is probably as rare in adult life, even when perfect function apparently proves its presence.

5. The question of what is the *normal refraction* of the human eye is still an open one, and further material on the subject and closer study of the data in hand will be necessary before drawing conclusions as to it. Much light will be thrown upon the question by studies like Risley's of the relations of normal vision, intraocular health, and functional comfort, to the refraction. For the present the conclusion of this author, whose work stands almost alone, may be accepted. "The emmetropic is the model or standard eye—since emmetropia is shown not only to remain nearly constant in percentage throughout the school life, but that it is also the condition of health, and withal enjoys the highest acuity of vision and the greatest freedom from pain."¹ Yet hypermetropia is the prevailing—almost the exclusive—condition of the refraction among most animals, among children, among uncivilized peoples, and among all eyes uninjured by the educational process.

1806 CHESTNUT ST.

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¹ The great majority of the eyes having exceptionally acute vision are hypermetropic, but, as shown, the majority of all eyes are H.

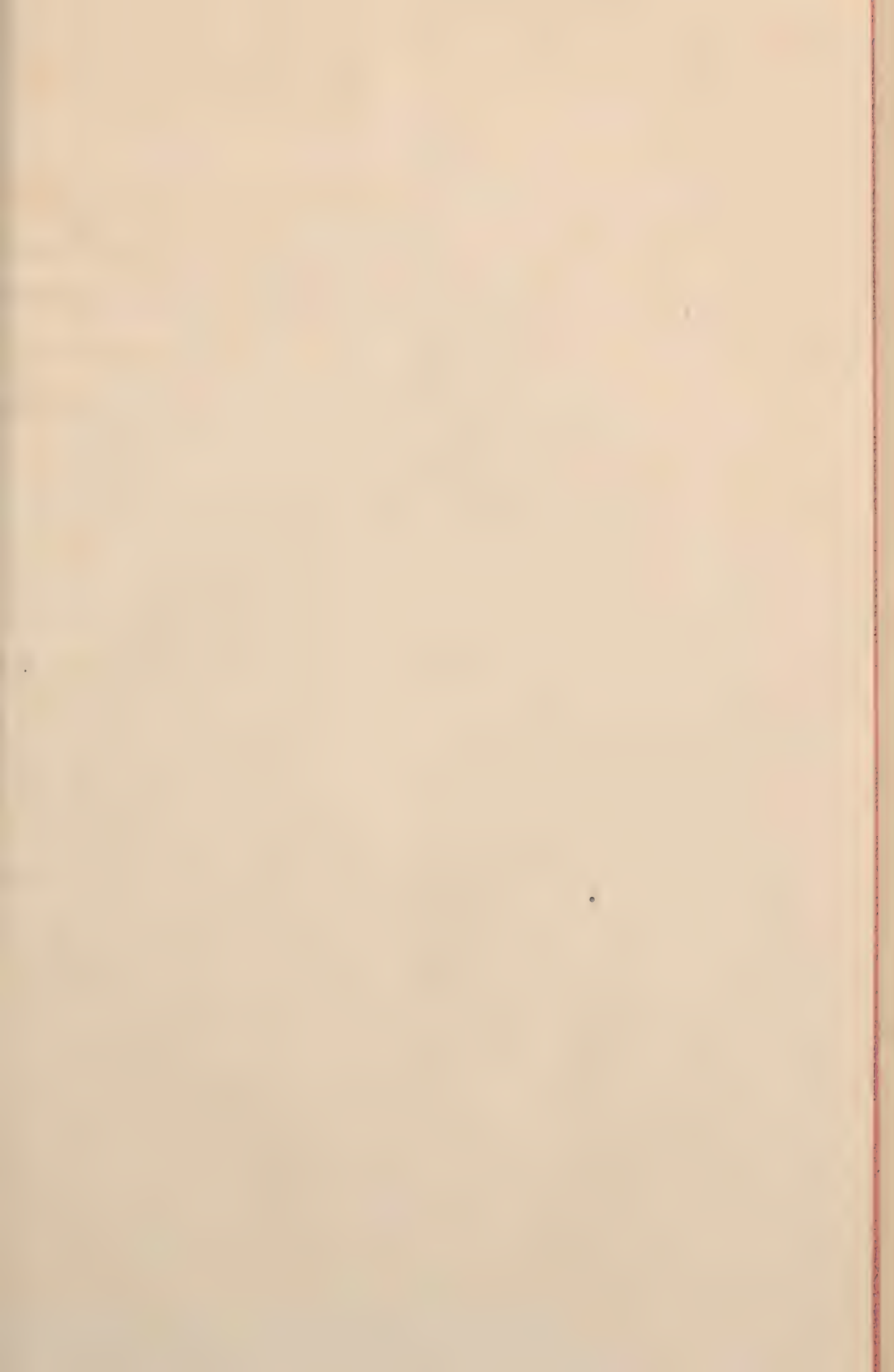
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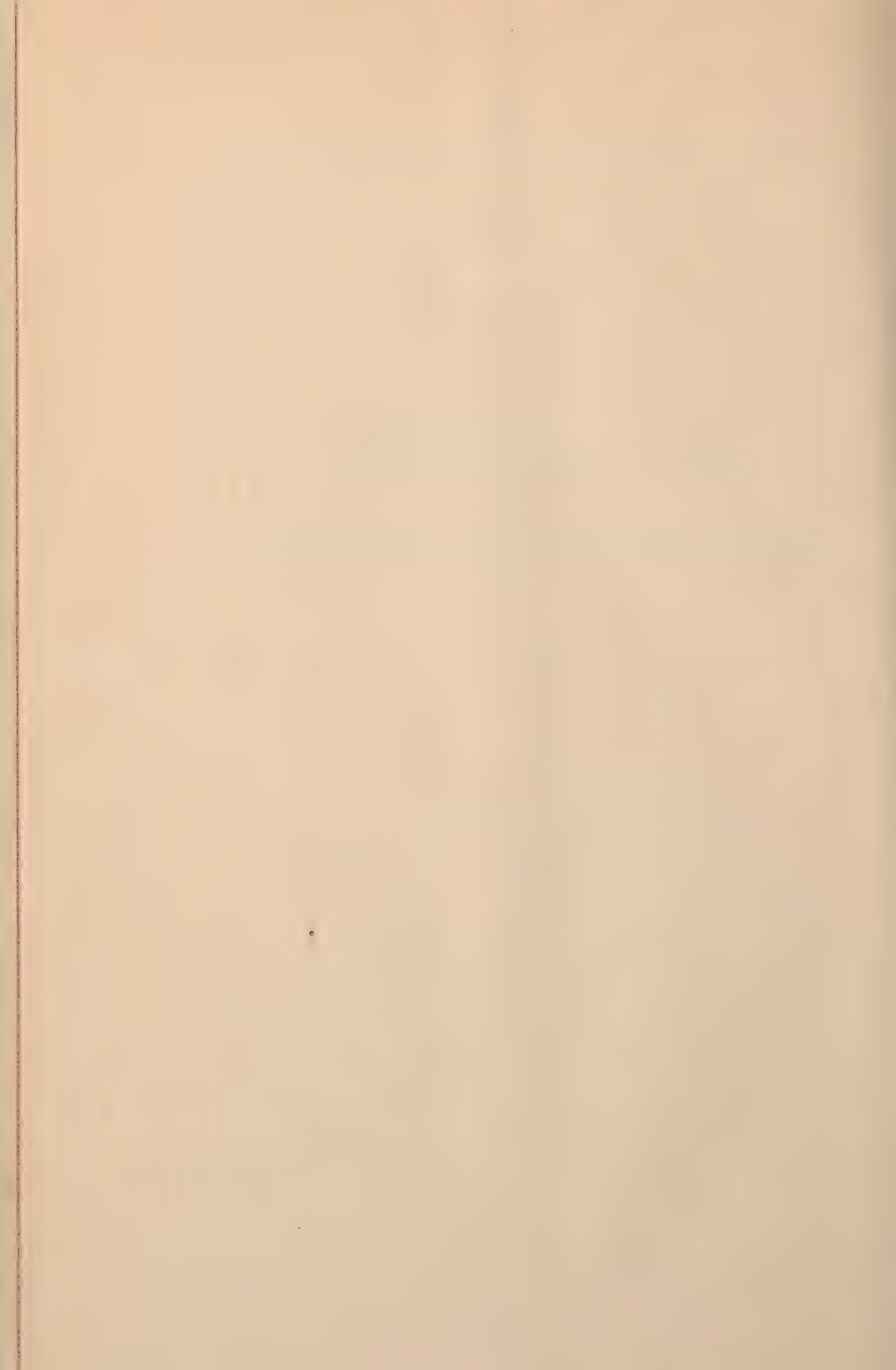
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1806 Chestnut St, Phila

Dear Doctor

In the accompanying paper the attempt has been made to collect all the investigations bearing upon the subject of the statistics of refraction; and nearly twice as many studies have been brought together as in any previous summary of which the writer has knowledge. Complete success could not be expected, although four years have been spent in collecting data; and of the records available, many are very incomplete. Believing that the subject is worthy of very much more extended and closer study the writer deems it allowable to appeal to all interested in this question and in the host of others growing out of it, to kindly furnish him with any further data which may be available, with amplifications of reports which have not been published in full and most especially with corrections of anything which he has not accurately represented

If you can kindly extend to him such aid
it will be gratefully acknowledged and
duly employed in the paper or papers in which
he proposes to continue this study. Criticism
as well as data will be gladly received, es-
pecially if any evidence of bias appears
in the treatment of the questions or facts un-
der consideration; and haste will be made
to correct any blunders which are pointed out.
It may be remarked that the writer has al-
ready gathered nearly one hundred of the
original records into his library, and has
access to many more; and he will continue
the effort to make the collection complete.
He hopes, therefore, that with the kind help
of the Profession his attempt to put these
statistics upon record in English will be
made a success, and engages to make the
fullest and most conscientiously ac-
curate use of all the data which he can
obtain.

Very respectfully
B. H. Randall.

John S. Billings M.D.
U.S.A.



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